

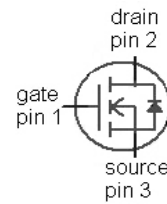
## OptiMOS<sup>®</sup> 3 Power-Transistor

### Features

- Fast switching MOSFET for SMPS
- Optimized technology for DC/DC converters
- Qualified according to JEDEC<sup>1)</sup> for target applications
- N-channel, logic level
- Excellent gate charge x  $R_{DS(on)}$  product (FOM)
- Very low on-resistance  $R_{DS(on)}$
- Avalanche rated
- Pb-free plating; RoHS compliant

### Product Summary

|                  |      |            |
|------------------|------|------------|
| $V_{DS}$         | 30   | V          |
| $R_{DS(on),max}$ | 13.5 | m $\Omega$ |
| $I_D$            | 30   | A          |



| Type    | IPD135N03L G | IPF135N03L G  | IPS135N03L G  | IPU135N03L G |
|---------|--------------|---------------|---------------|--------------|
|         |              |               |               |              |
| Package | PG-TO252-3   | PG-TO252-3-23 | PG-TO251-3-11 | PG-TO251-3   |
| Marking | 135N03L      | 135N03L       | 135N03L       | 135N03L      |

Maximum ratings, at  $T_j=25\text{ °C}$ , unless otherwise specified

| Parameter                                     | Symbol        | Conditions   | Value    | Unit              |
|---|---------------|--|----------|-------------------|
| Continuous drain current                      | $I_D$         | $V_{GS}=10\text{ V}, T_C=25\text{ °C}$   | 30       | A                 |
|   |               | $V_{GS}=10\text{ V}, T_C=100\text{ °C}$  | 26       |                   |
|   |               | $V_{GS}=4.5\text{ V}, T_C=25\text{ °C}$  | 30       |                   |
|   |               | $V_{GS}=4.5\text{ V}, T_C=100\text{ °C}$   | 21       |                   |
| Pulsed drain current <sup>2)</sup>            | $I_{D,pulse}$ | $T_C=25\text{ °C}$   | 210      |                   |
| Avalanche current, single pulse <sup>3)</sup> | $I_{AS}$      | $T_C=25\text{ °C}$   | 30       |                   |
| Avalanche energy, single pulse                | $E_{AS}$      | $I_D=10\text{ A}, R_{GS}=25\text{ }\Omega$   | 20       | mJ                |
| Reverse diode $dv/dt$                         | $dv/dt$       | $I_D=30\text{ A}, V_{DS}=24\text{ V}, di/dt=200\text{ A}/\mu\text{s}, T_{j,max}=175\text{ °C}$ | 6        | kV/ $\mu\text{s}$ |
| Gate source voltage                           | $V_{GS}$      |  | $\pm 20$ | V                 |

<sup>1)</sup> J-STD20 and JESD22

Maximum ratings, at  $T_j=25\text{ °C}$ , unless otherwise specified

| Parameter                           | Symbol                | Conditions         | Value       | Unit |
|-------------------------------------|-----------------------|--------------------|-------------|------|
| Power dissipation                   | $P_{\text{tot}}$      | $T_c=25\text{ °C}$ | 31          | W    |
| Operating and storage temperature   | $T_j, T_{\text{stg}}$ |                    | -55 ... 175 | °C   |
| IEC climatic category; DIN IEC 68-1 |                       |                    | 55/175/56   |      |

| Parameter | Symbol | Conditions | Values |      |      | Unit |
|-----------|--------|------------|--------|------|------|------|
|           |        |            | min.   | typ. | max. |      |

#### Thermal characteristics

|                                     |                   |  |   |   |     |     |
|-------------------------------------|-------------------|--|---|---|-----|-----|
| Thermal resistance, junction - case | $R_{\text{thJC}}$ |  | - | - | 4.9 | K/W |
| SMD version, device on PCB          | $R_{\text{thJA}}$ | minimal footprint                            | - | - | 75  |     |
|                                     |                   | 6 cm <sup>2</sup> cooling area <sup>4)</sup> | - | - | 50  |     |

Electrical characteristics, at  $T_j=25\text{ °C}$ , unless otherwise specified

#### Static characteristics

|  |                             |   |    |      |      |                  |
|--|-----------------------------|---|----|------|------|------------------|
| Drain-source breakdown voltage                 | $V_{(\text{BR})\text{DSS}}$ | $V_{\text{GS}}=0\text{ V}, I_{\text{D}}=1\text{ mA}$                            | 30 | -    | -    | V                |
| Gate threshold voltage                         | $V_{\text{GS(th)}}$         | $V_{\text{DS}}=V_{\text{GS}}, I_{\text{D}}=250\text{ }\mu\text{A}$              | 1  | -    | 2.2  |                  |
| Zero gate voltage drain current                | $I_{\text{DSS}}$            | $V_{\text{DS}}=30\text{ V}, V_{\text{GS}}=0\text{ V}, T_j=25\text{ °C}$         | -  | 0.1  | 1    | $\mu\text{A}$    |
|  |                             | $V_{\text{DS}}=30\text{ V}, V_{\text{GS}}=0\text{ V}, T_j=125\text{ °C}$        | -  | 10   | 100  |                  |
| Gate-source leakage current                    | $I_{\text{GSS}}$            | $V_{\text{GS}}=20\text{ V}, V_{\text{DS}}=0\text{ V}$                           | -  | 10   | 100  | nA               |
| Drain-source on-state resistance <sup>5)</sup> | $R_{\text{DS(on)}}$         | $V_{\text{GS}}=4.5\text{ V}, I_{\text{D}}=20\text{ A}$                          | -  | 16.4 | 20.5 | $\text{m}\Omega$ |
|  |                             | $V_{\text{GS}}=10\text{ V}, I_{\text{D}}=30\text{ A}$                           | -  | 11.3 | 13.5 |                  |
| Gate resistance                                | $R_{\text{G}}$              |   | -  | 1.2  | -    | $\Omega$         |
| Transconductance                               | $g_{\text{fs}}$             | $ V_{\text{DS}} >2 I_{\text{D}} R_{\text{DS(on)max}}, I_{\text{D}}=30\text{ A}$ | 22 | 43   | -    | S                |

<sup>2)</sup> See figure 3 for more detailed information

<sup>3)</sup> See figure 13 for more detailed information

<sup>4)</sup> Device on 40 mm x 40 mm x 1.5 mm epoxy PCB FR4 with 6 cm<sup>2</sup> (one layer, 70  $\mu\text{m}$  thick) copper area for drain connection. PCB is vertical in still air.

<sup>5)</sup> Measured from drain tab to source pin

| Parameter | Symbol | Conditions | Values |      |      | Unit |
|-----------|--------|------------|--------|------|------|------|
|           |        |            | min.   | typ. | max. |      |

#### Dynamic characteristics

|                              |              |   |   |     |      |    |
|------------------------------|--------------|---|---|-----|------|----|
| Input capacitance            | $C_{iss}$    | $V_{GS}=0\text{ V}, V_{DS}=15\text{ V},$<br>$f=1\text{ MHz}$                    | - | 770 | 1000 | pF |
| Output capacitance           | $C_{oss}$    |   | - | 350 | 470  |    |
| Reverse transfer capacitance | $C_{rss}$    |   | - | 16  | -    |    |
| Turn-on delay time           | $t_{d(on)}$  | $V_{DD}=15\text{ V}, V_{GS}=10\text{ V},$<br>$I_D=30\text{ A}, R_G=1.6\ \Omega$ | - | 3.0 | -    | ns |
| Rise time                    | $t_r$        |   | - | 3.0 | -    |    |
| Turn-off delay time          | $t_{d(off)}$ |   | - | 12  | -    |    |
| Fall time                    | $t_f$        |   | - | 2.2 | -    |    |

#### Gate Charge Characteristics<sup>6)</sup>

|                              |               |   |   |     |     |    |
|------------------------------|---------------|---|---|-----|-----|----|
| Gate to source charge        | $Q_{gs}$      | $V_{DD}=15\text{ V}, I_D=30\text{ A},$<br>$V_{GS}=0\text{ to }4.5\text{ V}$ | - | 2.7 | -   | nC |
| Gate charge at threshold     | $Q_{g(th)}$   |   | - | 1.2 | -   |    |
| Gate to drain charge         | $Q_{gd}$      |   | - | 1.2 | -   |    |
| Switching charge             | $Q_{sw}$      |   | - | 2.6 | -   |    |
| Gate charge total            | $Q_g$         |   | - | 4.8 | 6.4 |    |
| Gate plateau voltage         | $V_{plateau}$ |   | - | 3.5 | -   |    |
| Gate charge total            | $Q_g$         | $V_{DD}=15\text{ V}, I_D=30\text{ A},$<br>$V_{GS}=0\text{ to }10\text{ V}$  | - | 10  | -   | nC |
| Gate charge total, sync. FET | $Q_{g(sync)}$ | $V_{DS}=0.1\text{ V},$<br>$V_{GS}=0\text{ to }4.5\text{ V}$                 | - | 4.2 | 5.5 |    |
| Output charge                | $Q_{oss}$     | $V_{DD}=15\text{ V}, V_{GS}=0\text{ V}$                                     | - | 9   | -   |    |

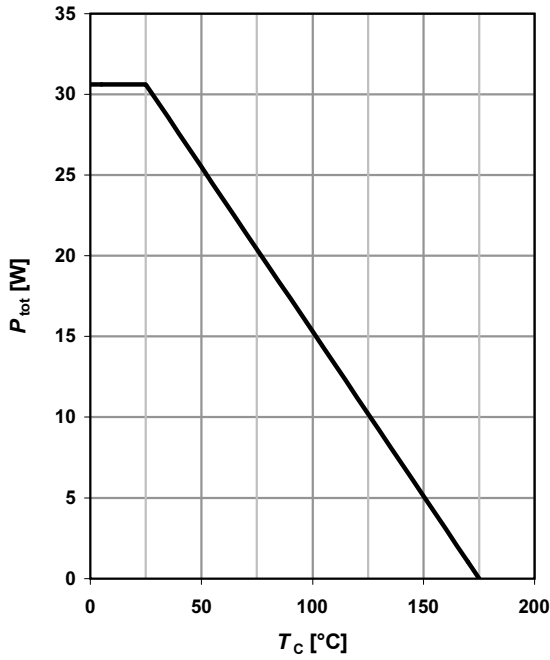
#### Reverse Diode

|                                  |               |   |   |      |     |    |
|----------------------------------|---------------|---|---|------|-----|----|
| Diode continuous forward current | $I_S$         | $T_C=25\text{ }^\circ\text{C}$  | - | -    | 25  | A  |
| Diode pulse current              | $I_{S,pulse}$ |   | - | -    | 210 |    |
| Diode forward voltage            | $V_{SD}$      | $V_{GS}=0\text{ V}, I_F=30\text{ A},$<br>$T_j=25\text{ }^\circ\text{C}$ | - | 0.98 | 1.2 | V  |
| Reverse recovery charge          | $Q_{rr}$      | $V_R=15\text{ V}, I_F=I_S,$<br>$di_F/dt=400\text{ A}/\mu\text{s}$       | - | -    | 10  | nC |

<sup>6)</sup> See figure 16 for gate charge parameter definition

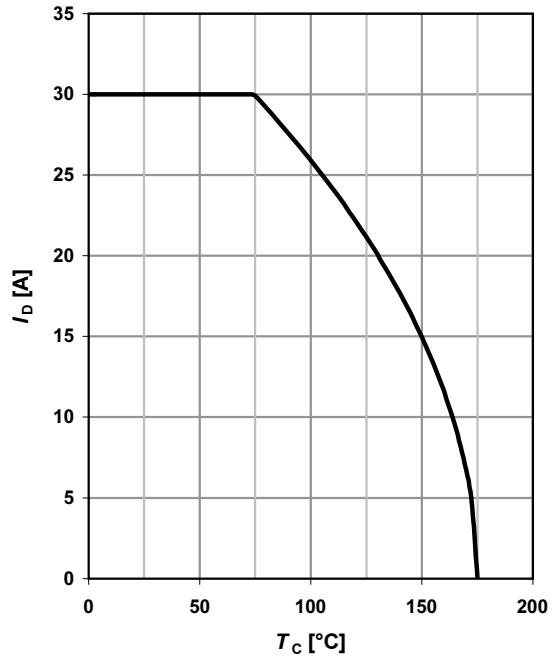
**1 Power dissipation**

$P_{tot}=f(T_C)$



**2 Drain current**

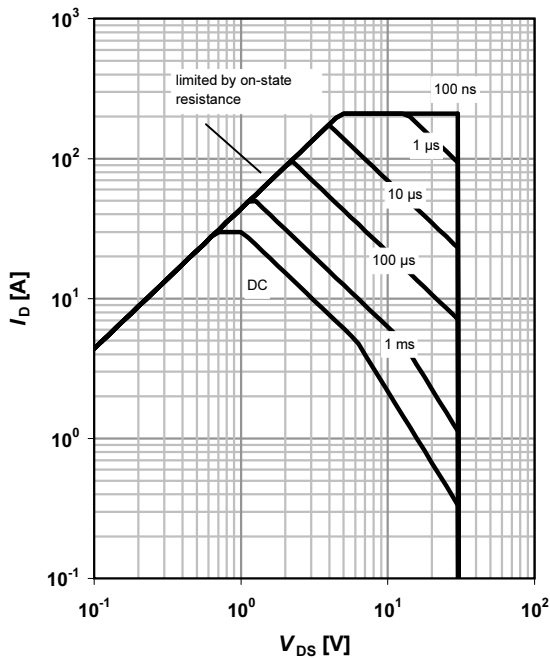
$I_D=f(T_C); V_{GS} \geq 10\text{ V}$



**3 Safe operating area**

$I_D=f(V_{DS}); T_C=25\text{ °C}; D=0$

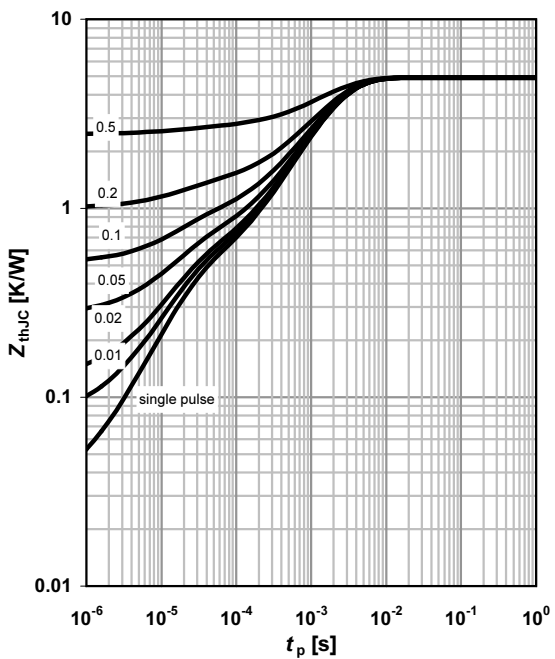
parameter:  $t_p$



**4 Max. transient thermal impedance**

$Z_{thJC}=f(t_p)$

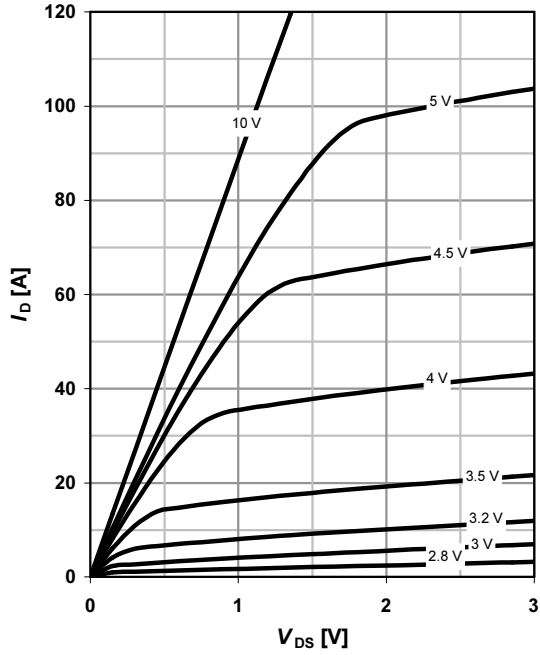
parameter:  $D=t_p/T$



**5 Typ. output characteristics**

$I_D = f(V_{DS}); T_j = 25\text{ }^\circ\text{C}$

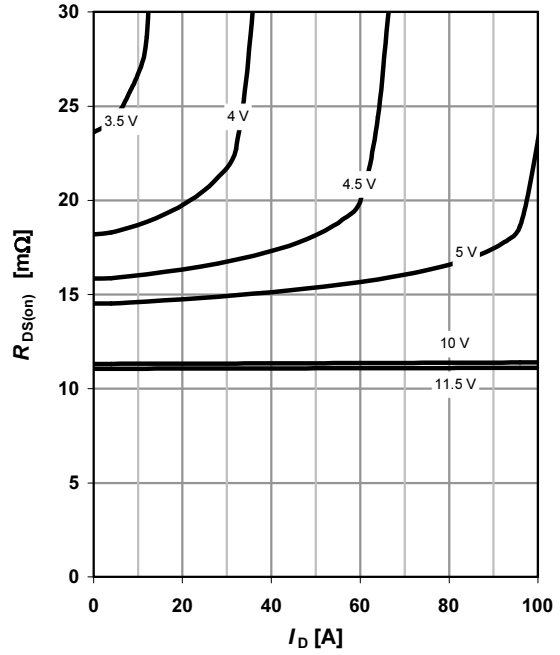
parameter:  $V_{GS}$



**6 Typ. drain-source on resistance**

$R_{DS(on)} = f(I_D); T_j = 25\text{ }^\circ\text{C}$

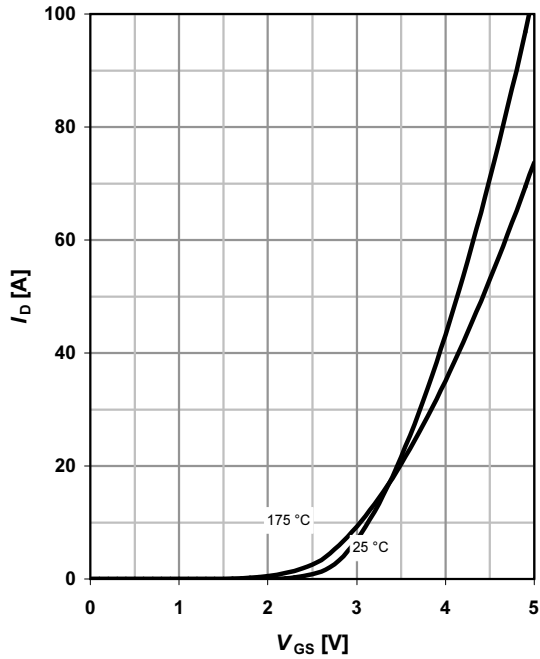
parameter:  $V_{GS}$



**7 Typ. transfer characteristics**

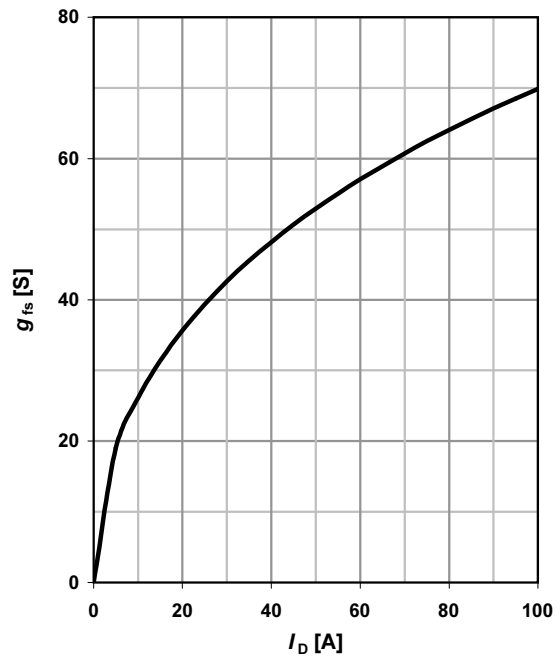
$I_D = f(V_{GS}); |V_{DS}| > 2|I_D|R_{DS(on)max}$

parameter:  $T_j$



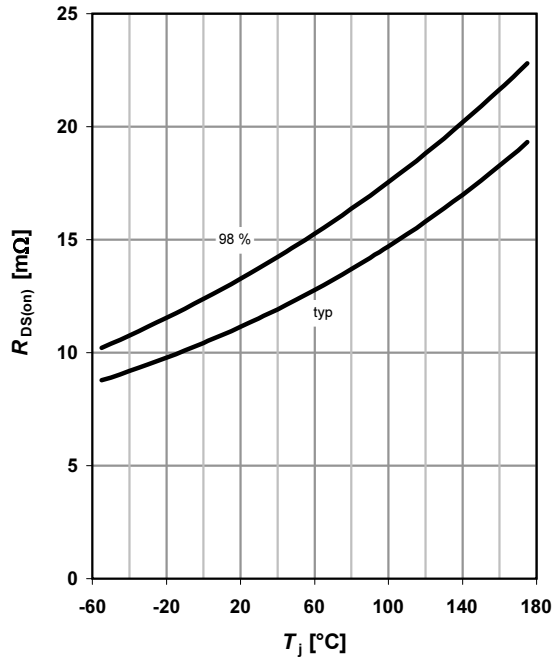
**8 Typ. forward transconductance**

$g_{fs} = f(I_D); T_j = 25\text{ }^\circ\text{C}$



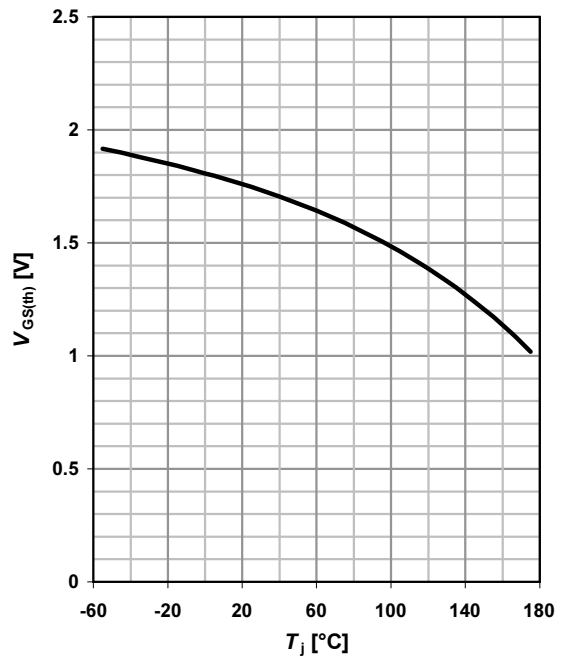
**9 Drain-source on-state resistance**

$R_{DS(on)} = f(T_j); I_D = 30 \text{ A}; V_{GS} = 10 \text{ V}$



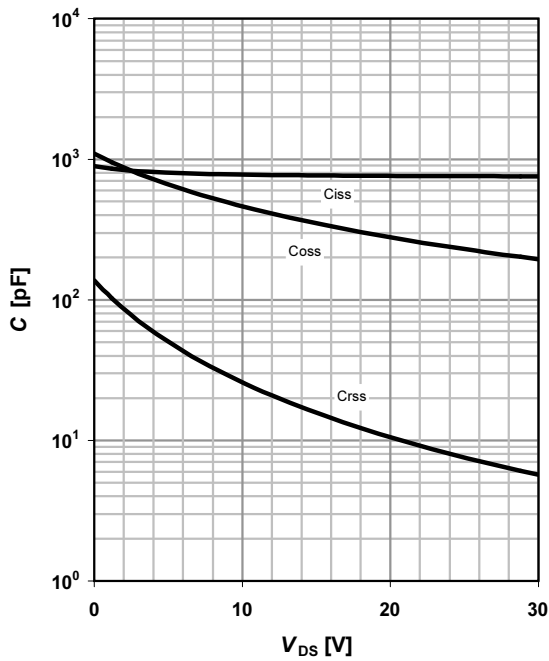
**10 Typ. gate threshold voltage**

$V_{GS(th)} = f(T_j); V_{GS} = V_{DS}; I_D = 250 \mu\text{A}$



**11 Typ. capacitances**

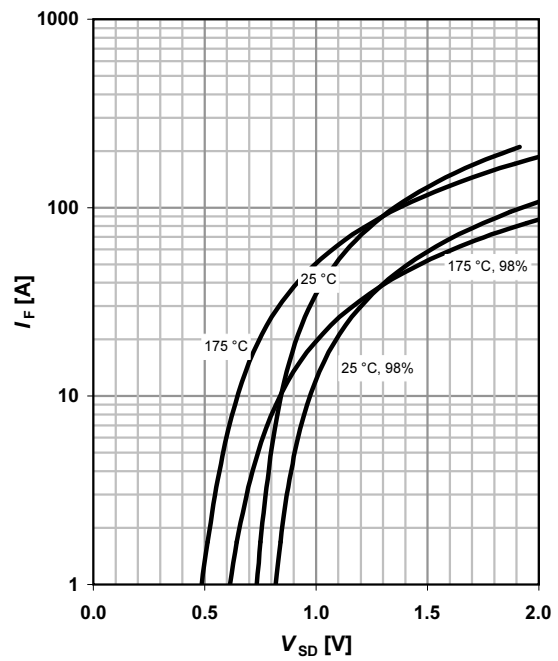
$C = f(V_{DS}); V_{GS} = 0 \text{ V}; f = 1 \text{ MHz}$



**12 Forward characteristics of reverse diode**

$I_F = f(V_{SD})$

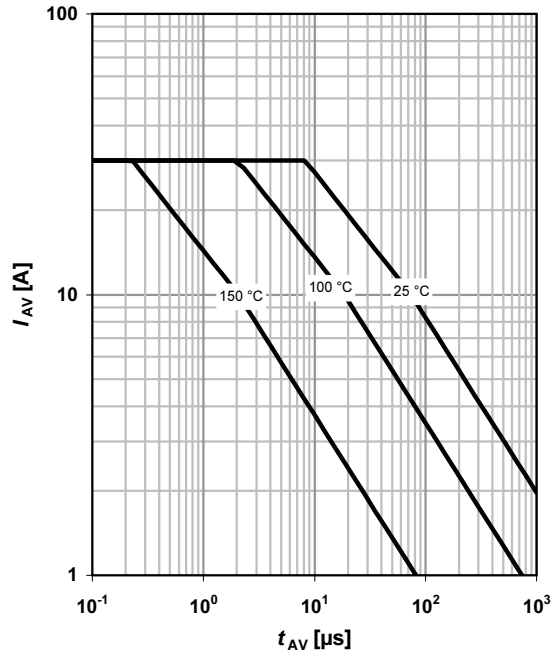
parameter:  $T_j$



### 13 Avalanche characteristics

$$I_{AS} = f(t_{AV}); R_{GS} = 25 \Omega$$

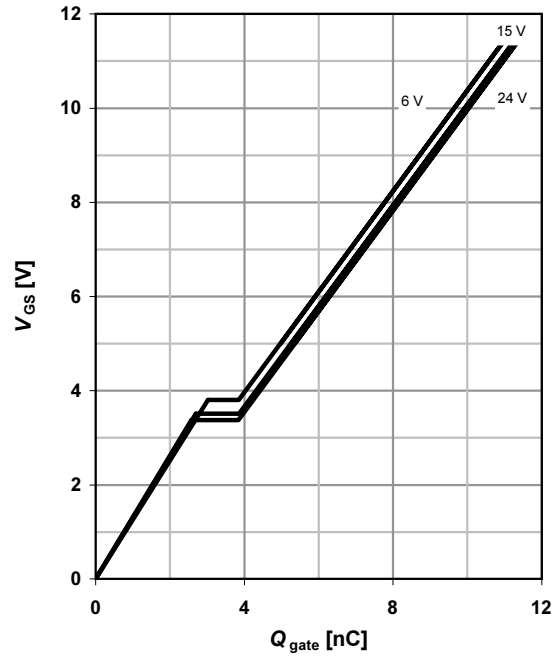
parameter:  $T_{j(\text{start})}$



### 14 Typ. gate charge

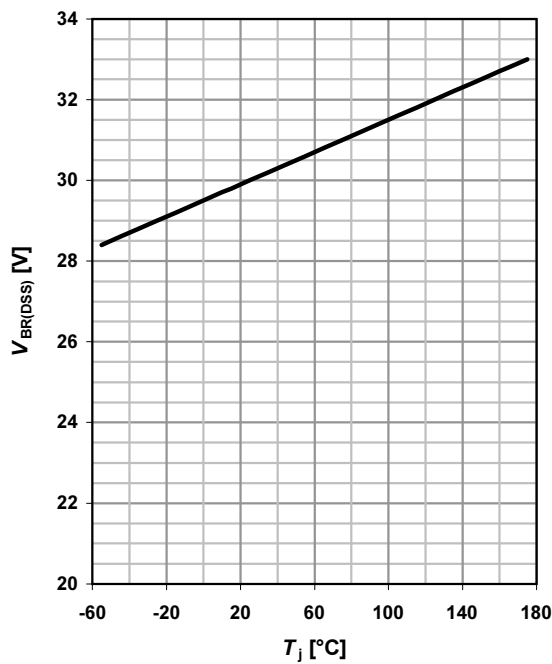
$$V_{GS} = f(Q_{\text{gate}}); I_D = 30 \text{ A pulsed}$$

parameter:  $V_{DD}$

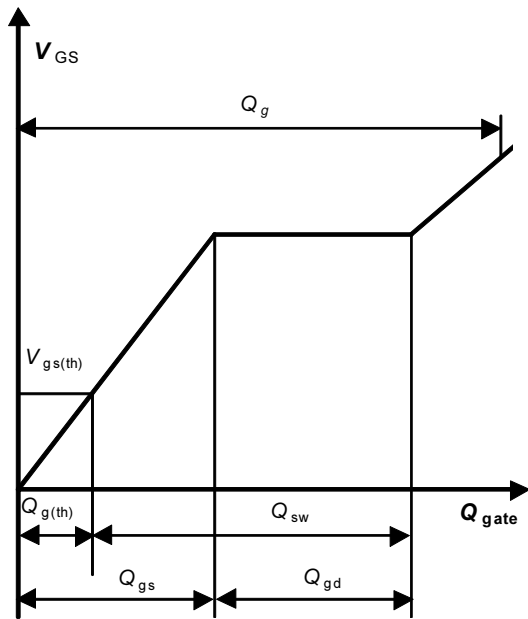


### 15 Drain-source breakdown voltage

$$V_{BR(DSS)} = f(T_j); I_D = 1 \text{ mA}$$

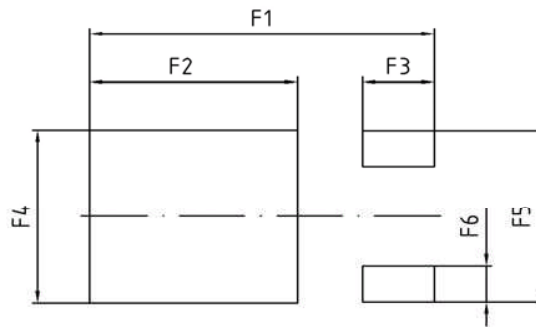
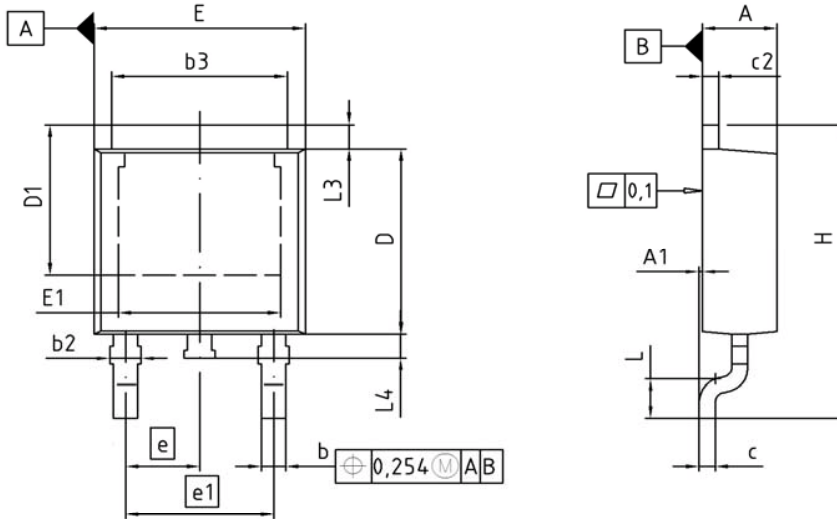


### 16 Gate charge waveforms



Package Outline

PG-TO252-3



| DIM | MILLIMETERS |       | INCHES |       |
|-----|-------------|-------|--------|-------|
|     | MIN         | MAX   | MIN    | MAX   |
| A   | 2.16        | 2.41  | 0.085  | 0.095 |
| A1  | 0.00        | 0.15  | 0.000  | 0.006 |
| b   | 0.64        | 0.89  | 0.025  | 0.035 |
| b2  | 0.65        | 1.15  | 0.026  | 0.045 |
| b3  | 5.00        | 5.50  | 0.197  | 0.217 |
| c   | 0.46        | 0.60  | 0.018  | 0.024 |
| c2  | 0.46        | 0.98  | 0.018  | 0.039 |
| D   | 5.97        | 6.22  | 0.235  | 0.245 |
| D1  | 5.02        | 5.84  | 0.198  | 0.230 |
| E   | 6.40        | 6.73  | 0.252  | 0.265 |
| E1  | 4.70        | 5.21  | 0.185  | 0.205 |
| e   | 2.29        |       | 0.090  |       |
| e1  | 4.57        |       | 0.180  |       |
| N   | 3           |       | 3      |       |
| H   | 9.40        | 10.48 | 0.370  | 0.413 |
| L   | 1.18        | 1.70  | 0.046  | 0.067 |
| L3  | 0.90        | 1.25  | 0.035  | 0.049 |
| L4  | 0.51        | 1.00  | 0.020  | 0.039 |
| F1  | 10.50       | 10.70 | 0.413  | 0.421 |
| F2  | 6.30        | 6.50  | 0.248  | 0.256 |
| F3  | 2.10        | 2.30  | 0.083  | 0.091 |
| F4  | 5.70        | 5.90  | 0.224  | 0.232 |
| F5  | 5.66        | 5.86  | 0.223  | 0.231 |
| F6  | 1.10        | 1.30  | 0.043  | 0.051 |

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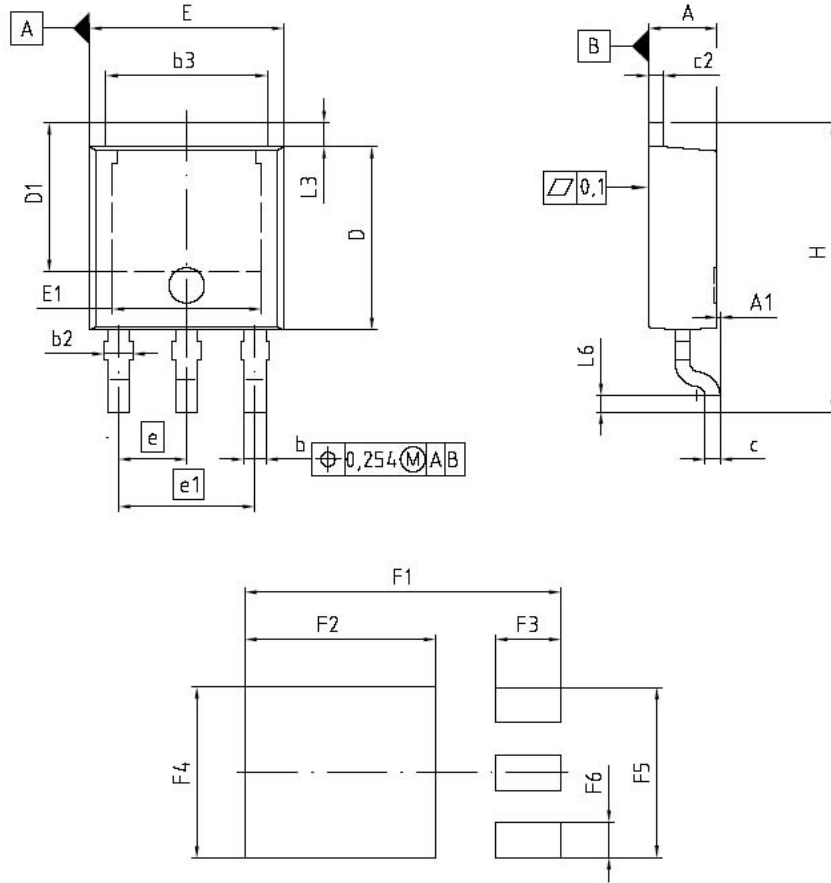
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03



Package Outline

PG-TO252-3-23



| DIM | MILLIMETERS |        | INCHES |       |
|-----|-------------|--------|--------|-------|
|     | MIN         | MAX    | MIN    | MAX   |
| A   | 2.159       | 2.413  | 0.085  | 0.096 |
| A1  | 0.000       | 0.150  | 0.000  | 0.006 |
| b   | 0.635       | 0.889  | 0.025  | 0.035 |
| b2  | 0.650       | 1.150  | 0.026  | 0.045 |
| b3  | 5.004       | 5.500  | 0.197  | 0.217 |
| c   | 0.457       | 0.580  | 0.018  | 0.023 |
| e2  | 0.460       | 0.980  | 0.018  | 0.039 |
| D   | 5.969       | 6.223  | 0.235  | 0.245 |
| D1  | 5.020       | 5.642  | 0.198  | 0.230 |
| E   | 6.400       | 6.731  | 0.252  | 0.265 |
| E1  | 4.850       | 5.207  | 0.191  | 0.205 |
| e   | 2.286       |        | 0.090  |       |
| e1  | 4.572       |        | 0.180  |       |
| N   | 3           |        | 3      |       |
| H   | 9.400       | 10.480 | 0.370  | 0.413 |
| L3  | 0.900       | 1.143  | 0.035  | 0.045 |
| L4  | 0.584       | 0.950  | 0.023  | 0.037 |
| L6  | 0.510       | 0.696  | 0.020  | 0.027 |
| F1  | 10.500      | 10.700 | 0.413  | 0.421 |
| F2  | 6.300       | 6.500  | 0.248  | 0.256 |
| F3  | 2.100       | 2.300  | 0.083  | 0.091 |
| F4  | 5.700       | 5.900  | 0.224  | 0.232 |
| F5  | 5.660       | 5.860  | 0.222  | 0.231 |
| F6  | 1.100       | 1.300  | 0.043  | 0.051 |

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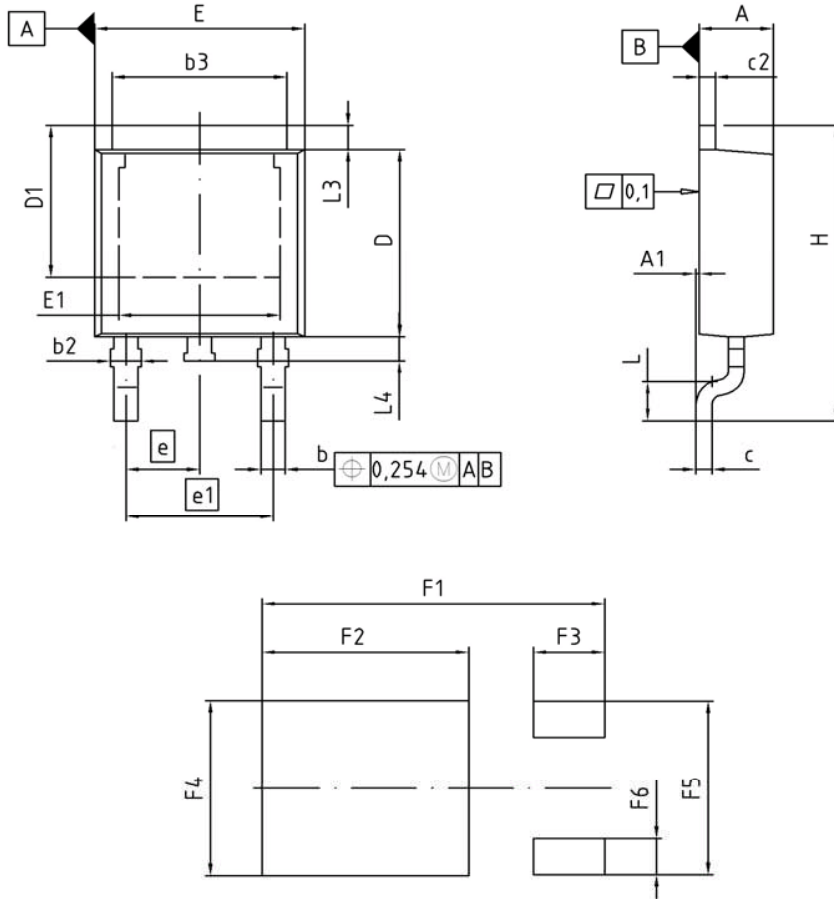
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TO252\_2

Package Outline

PG-TO251-3-11



| DIM | MILLIMETERS |       | INCHES |       |
|-----|-------------|-------|--------|-------|
|     | MIN         | MAX   | MIN    | MAX   |
| A   | 2.16        | 2.41  | 0.085  | 0.095 |
| A1  | 0.00        | 0.15  | 0.000  | 0.006 |
| b   | 0.64        | 0.89  | 0.025  | 0.035 |
| b2  | 0.65        | 1.15  | 0.026  | 0.045 |
| b3  | 5.00        | 5.50  | 0.197  | 0.217 |
| c   | 0.46        | 0.60  | 0.018  | 0.024 |
| c2  | 0.46        | 0.98  | 0.018  | 0.039 |
| D   | 5.97        | 6.22  | 0.235  | 0.245 |
| D1  | 5.02        | 5.84  | 0.198  | 0.230 |
| E   | 6.40        | 6.73  | 0.252  | 0.265 |
| E1  | 4.70        | 5.21  | 0.185  | 0.205 |
| e   | 2.29        |       | 0.090  |       |
| e1  | 4.57        |       | 0.180  |       |
| N   | 3           |       | 3      |       |
| H   | 9.40        | 10.48 | 0.370  | 0.413 |
| L   | 1.18        | 1.70  | 0.046  | 0.067 |
| L3  | 0.90        | 1.25  | 0.035  | 0.049 |
| L4  | 0.51        | 1.00  | 0.020  | 0.039 |
| F1  | 10.50       | 10.70 | 0.413  | 0.421 |
| F2  | 6.30        | 6.50  | 0.248  | 0.256 |
| F3  | 2.10        | 2.30  | 0.083  | 0.091 |
| F4  | 5.70        | 5.90  | 0.224  | 0.232 |
| F5  | 5.66        | 5.86  | 0.223  | 0.231 |
| F6  | 1.10        | 1.30  | 0.043  | 0.051 |

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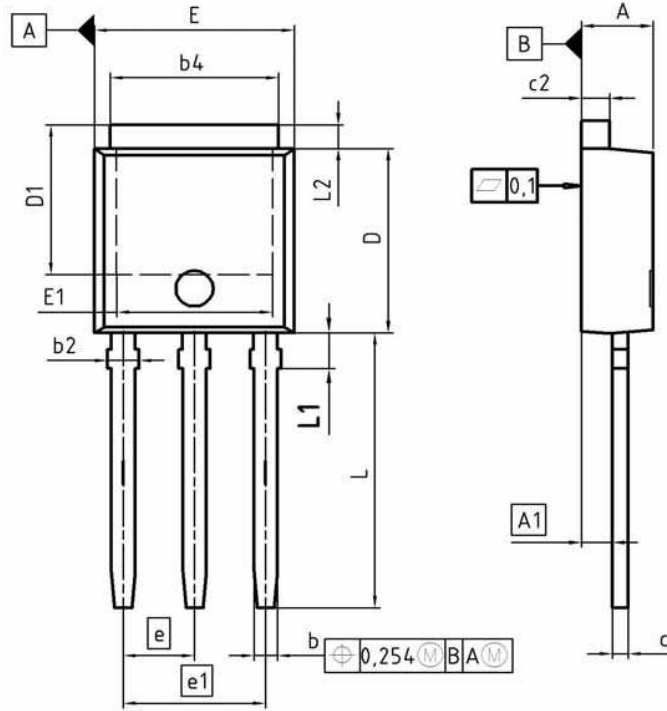
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Package Outline

PG-TO251-3



| DIM | MILLIMETERS |      | INCHES |       |
|-----|-------------|------|--------|-------|
|     | MIN         | MAX  | MIN    | MAX   |
| A   | 2.16        | 2.41 | 0.085  | 0.095 |
| A1  | 0.90        | 1.14 | 0.035  | 0.045 |
| b   | 0.64        | 0.89 | 0.025  | 0.035 |
| b2  | 0.65        | 1.15 | 0.026  | 0.045 |
| b4  | 4.95        | 5.50 | 0.195  | 0.217 |
| c   | 0.46        | 0.60 | 0.018  | 0.024 |
| c2  | 0.46        | 0.89 | 0.018  | 0.035 |
| D   | 5.97        | 6.22 | 0.235  | 0.245 |
| D1  | 5.04        | 5.77 | 0.198  | 0.227 |
| E   | 6.35        | 6.73 | 0.250  | 0.265 |
| E1  | 4.70        | 5.21 | 0.185  | 0.205 |
| e   | 2.29        |      | 0.090  |       |
| e1  | 4.57        |      | 0.180  |       |
| N   | 3           |      | 3      |       |
| L   | 8.89        | 9.65 | 0.350  | 0.380 |
| L1  | 1.90        | 2.29 | 0.075  | 0.090 |
| L2  | 0.89        | 1.37 | 0.035  | 0.054 |

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IPS135N03L G      IPU135N03L G

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